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Mizuno

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[54] **DISPENSING DEVICE AND IMMUNOASSAY APPARATUS USING THE SAME**

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[51] Int. Cl.⁶ **B01L 3/02**

[52] U.S. Cl. **422/100; 422/63; 422/64; 422/65; 422/67; 436/180**

[58] Field of Search 422/62, 63, 64, 422/65, 67, 68.1, 100, 103; 436/179, 180

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Primary Examiner—Harold Y. Pyon

[57] **ABSTRACT**

A dispensing device, which may be used with an immunoassay apparatus, includes at least two dispensing pipettes for sucking and discharging liquid; a pipette elevating device for selectively raising and lowering each pipette along an elevating path thereof; a base for holding the pipette elevating device; a base moving device for moving the base; a washing vessel in which each pipette is alternately immersed to be cleaned; and a washing vessel moving device for allowing the washing vessel to selectively move between locations in the elevating paths of the pipettes.

11 Claims, 12 Drawing Sheets

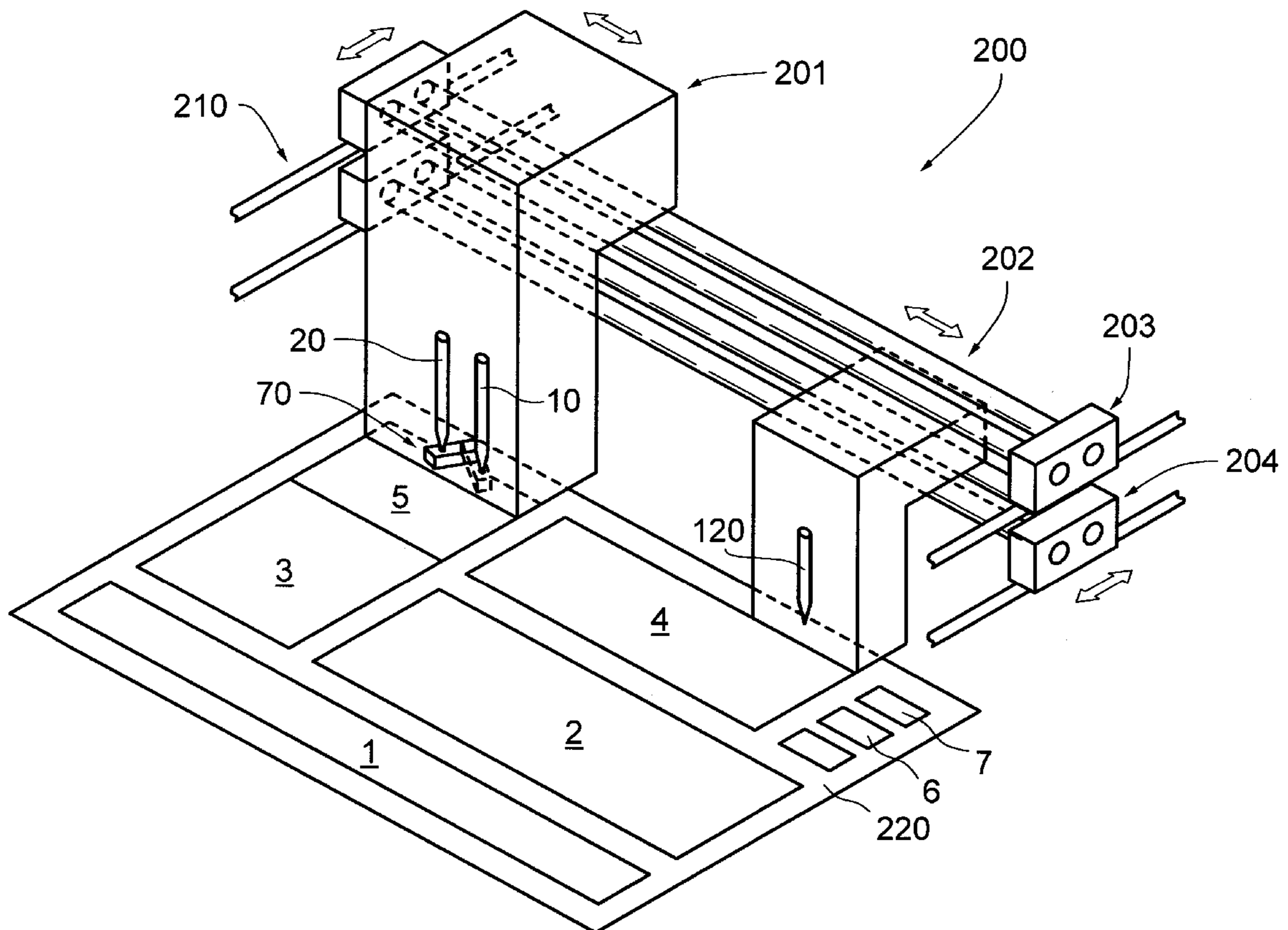


FIG. 1

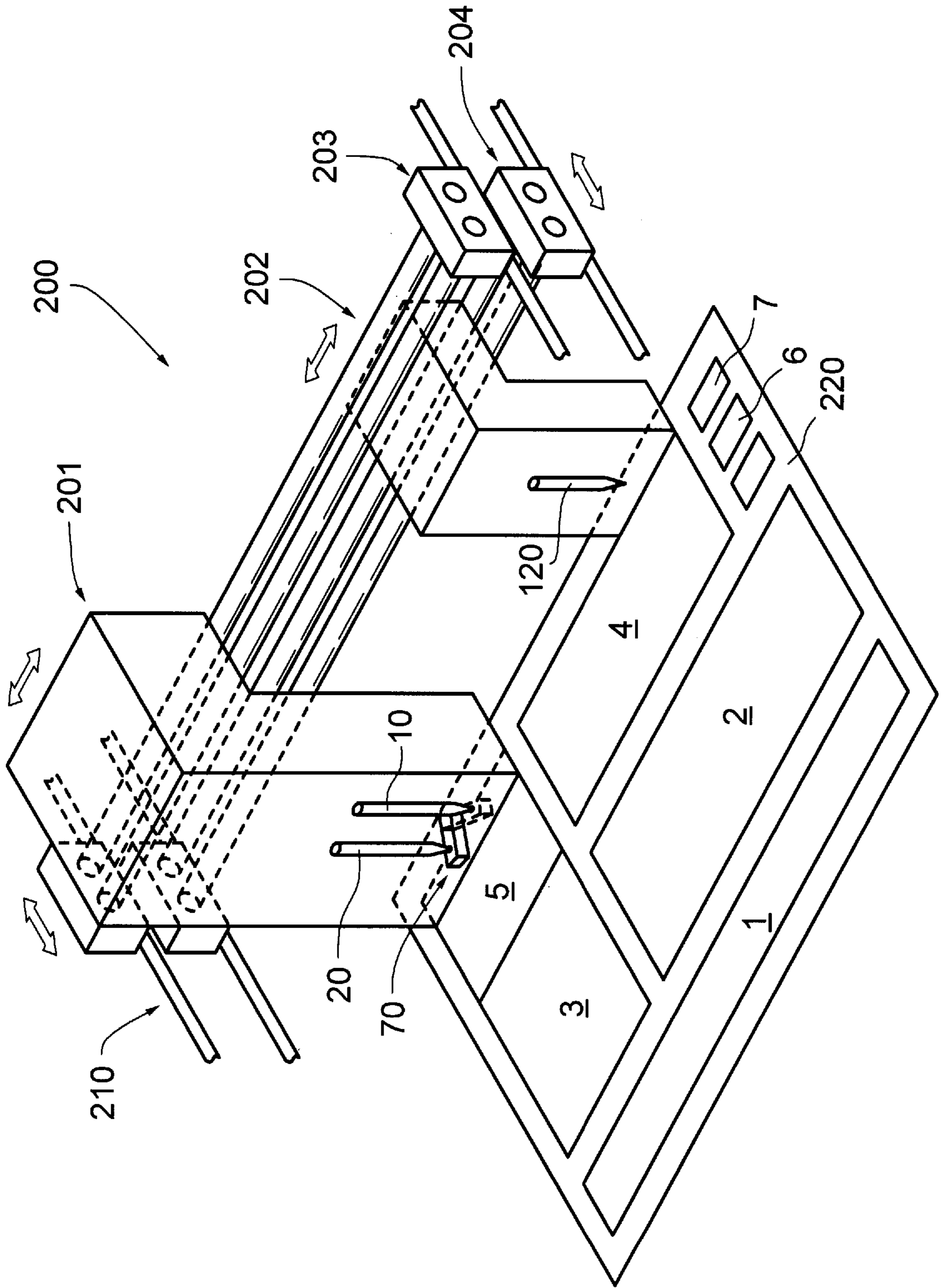


FIG. 2

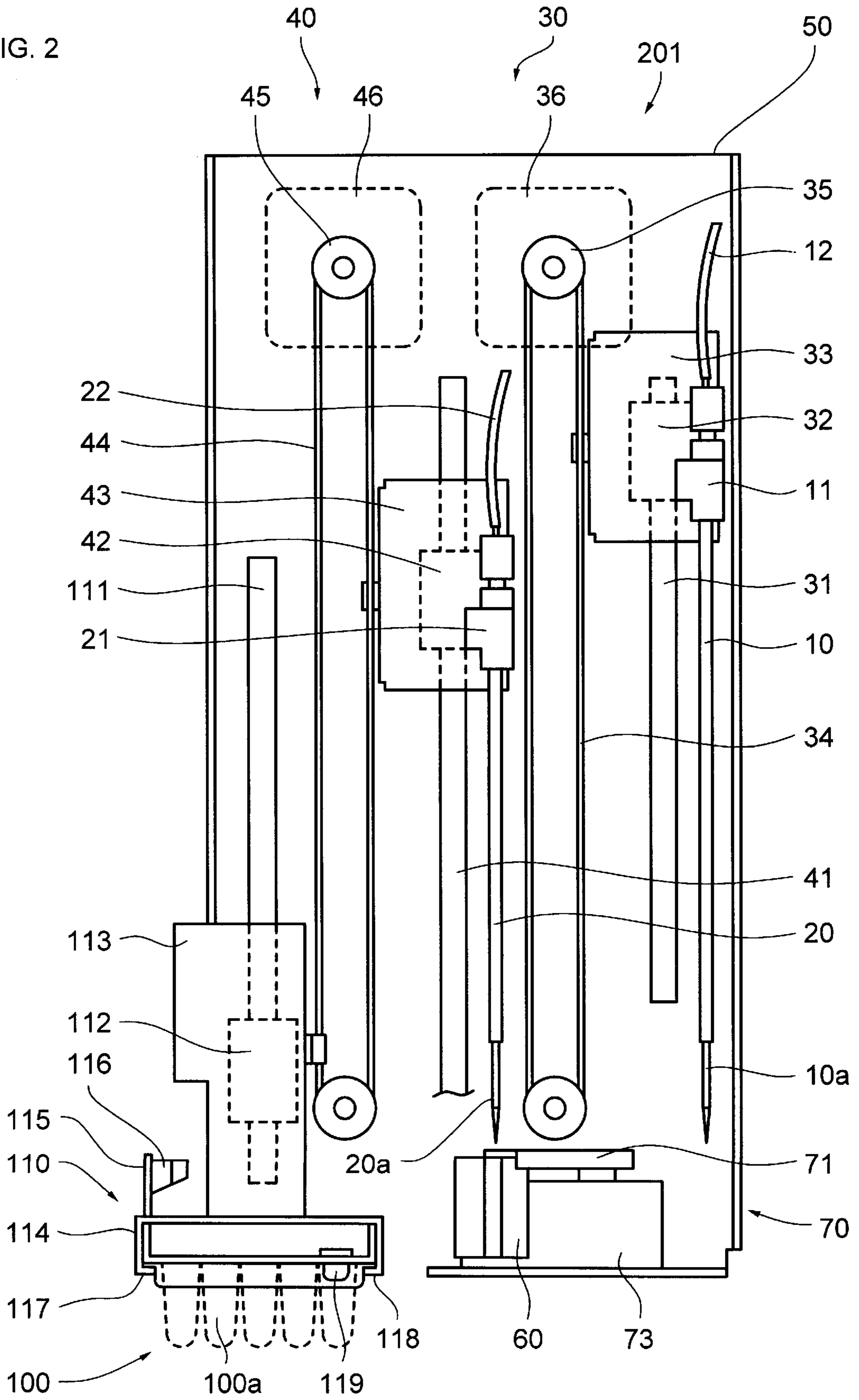


FIG. 3

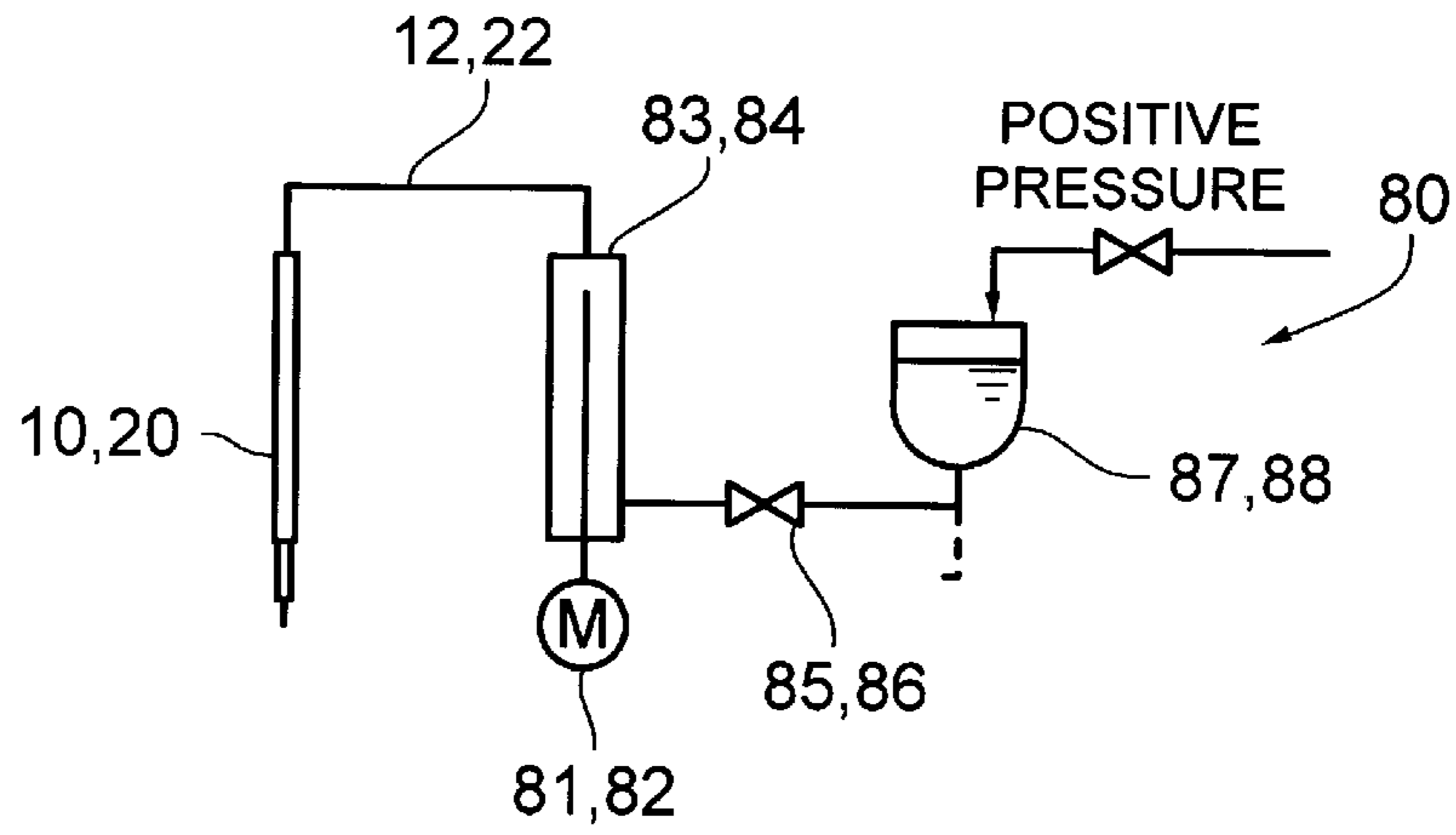


FIG. 4

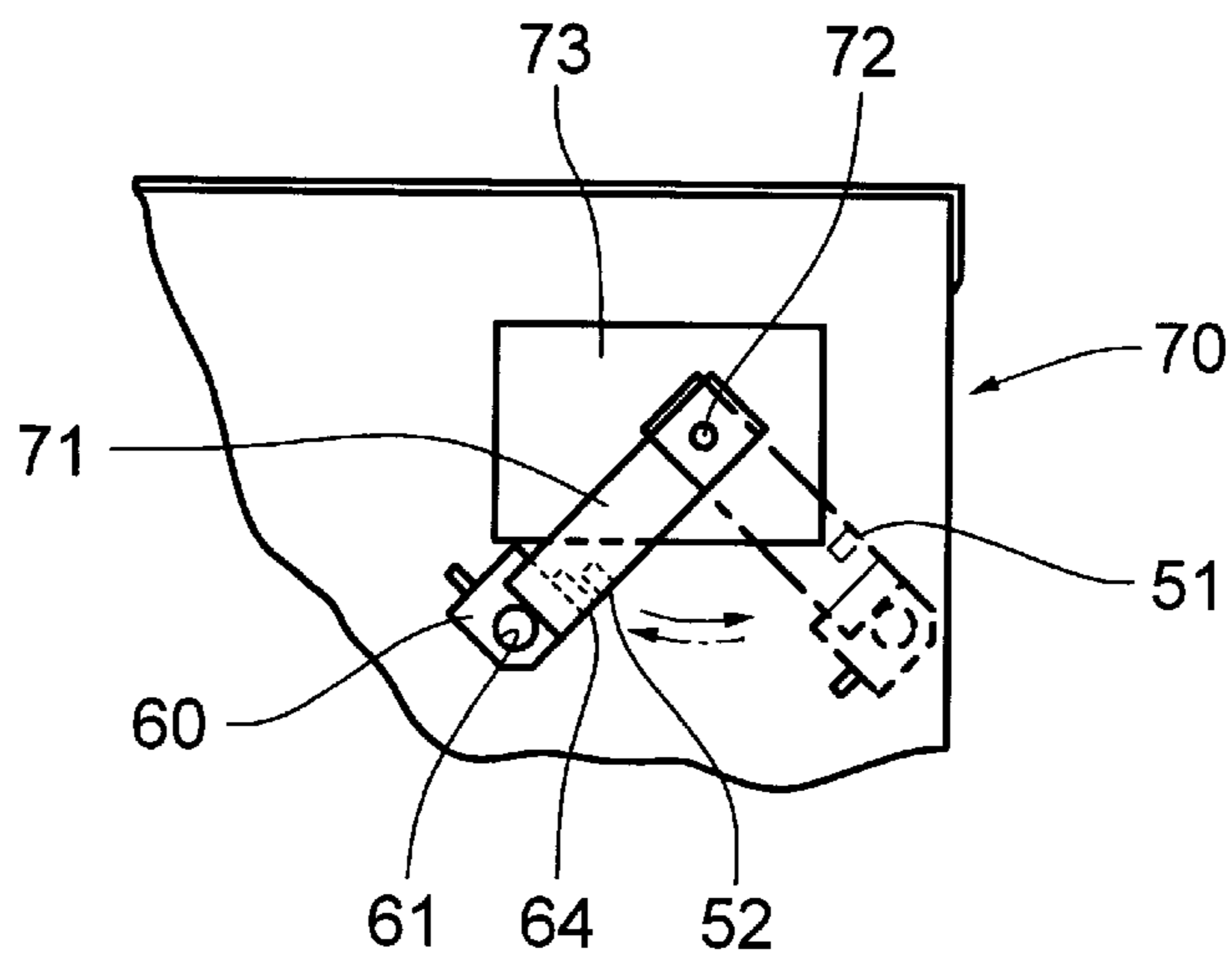
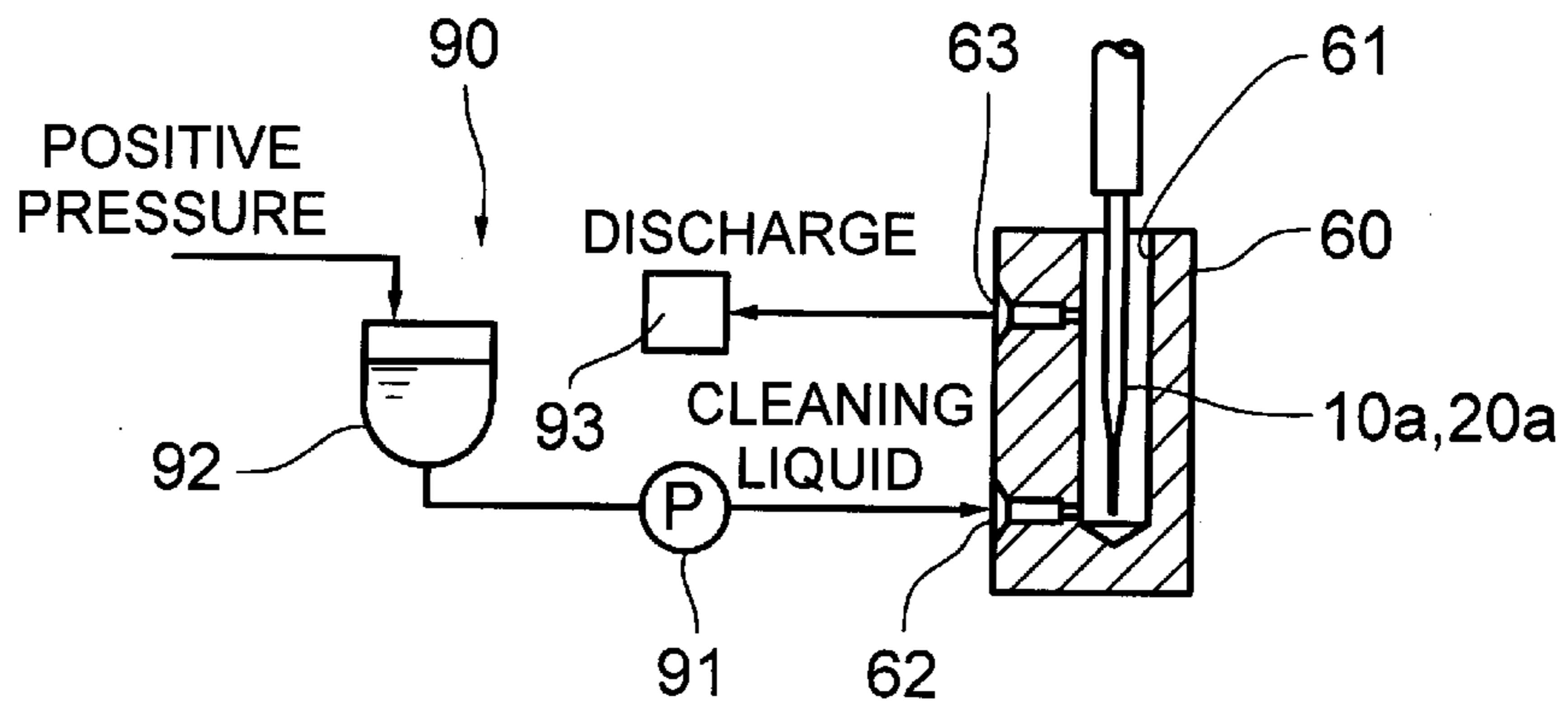


FIG. 5



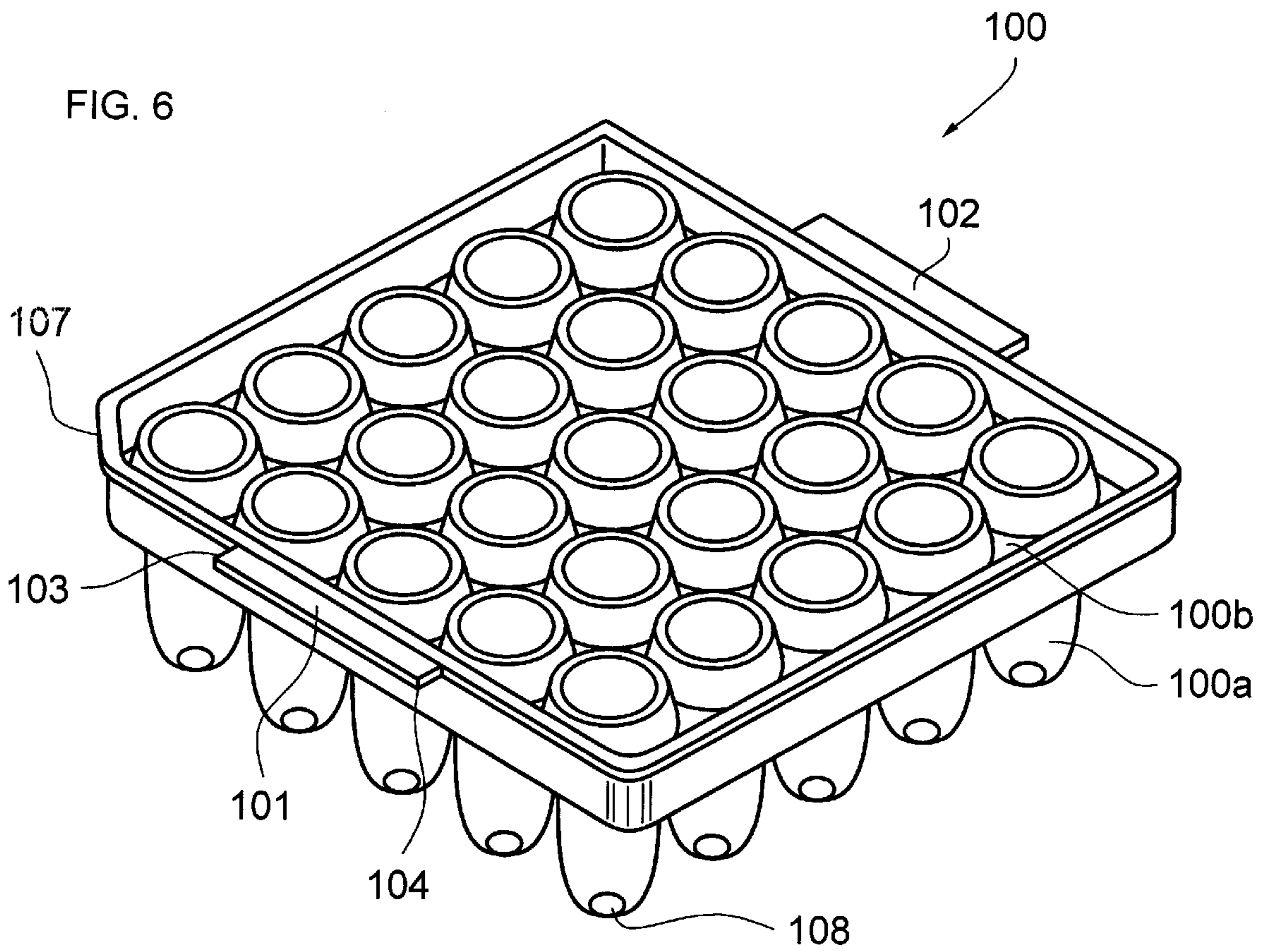


FIG. 7

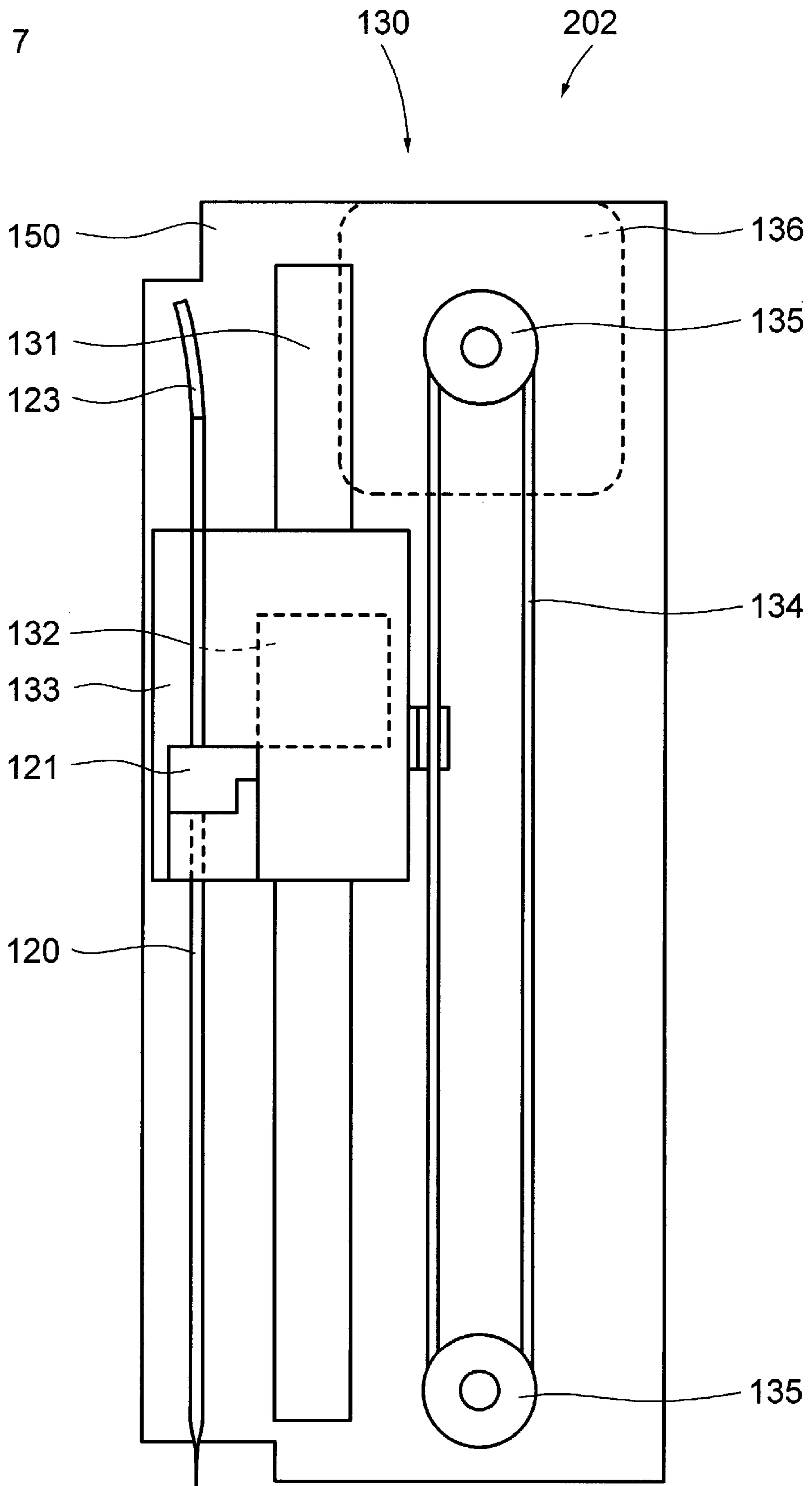


FIG. 8

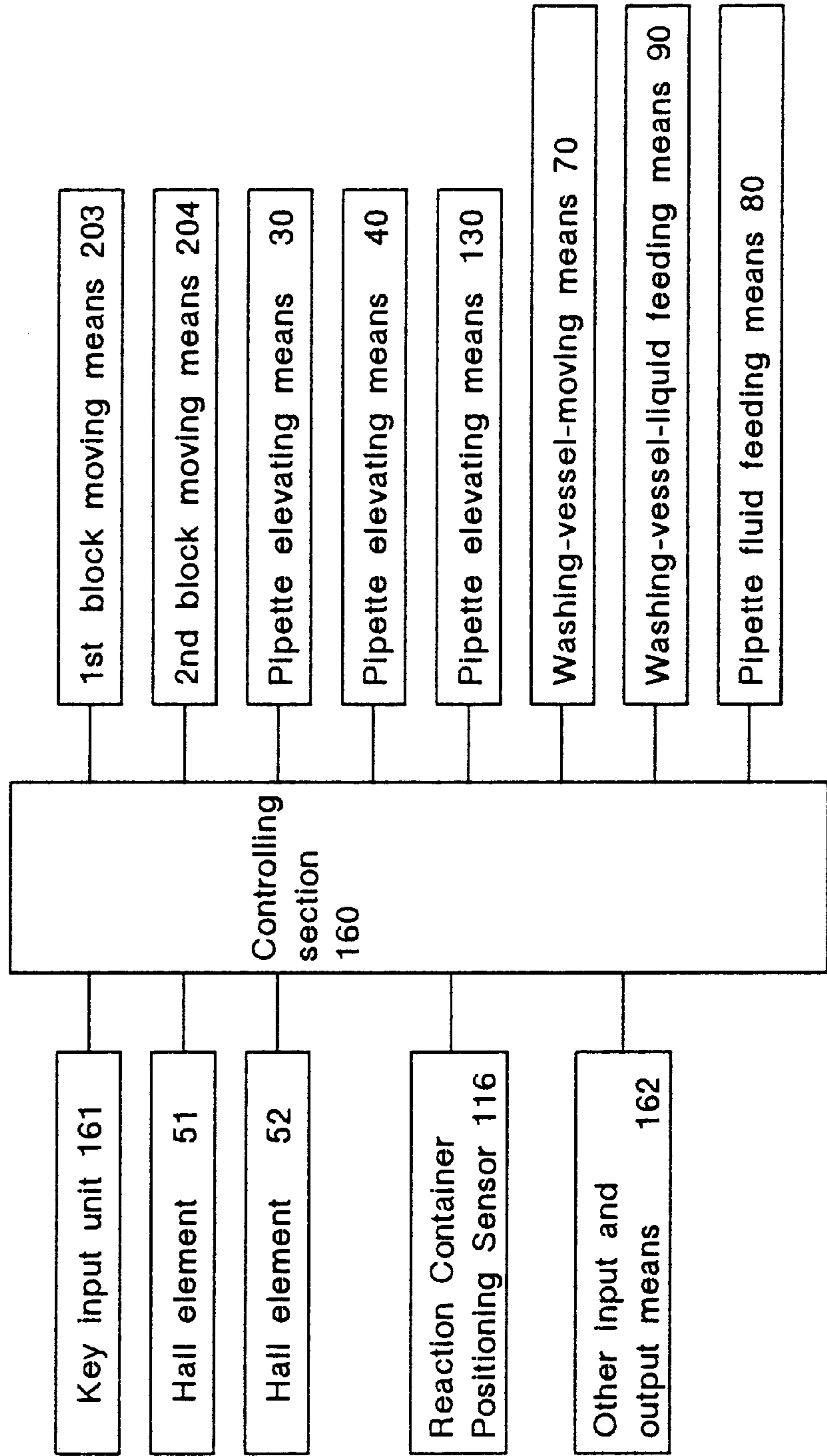


FIG. 9

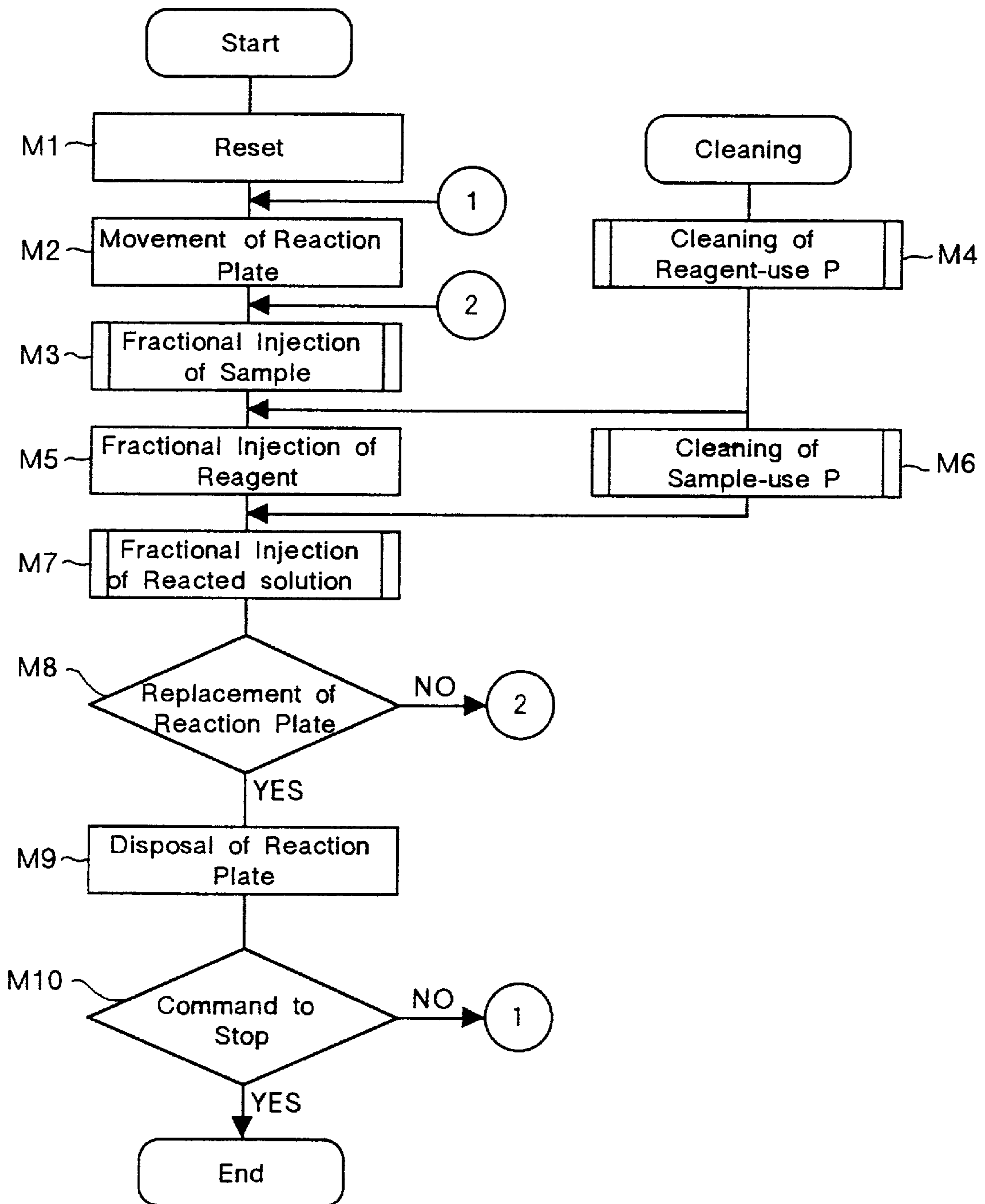


FIG. 10

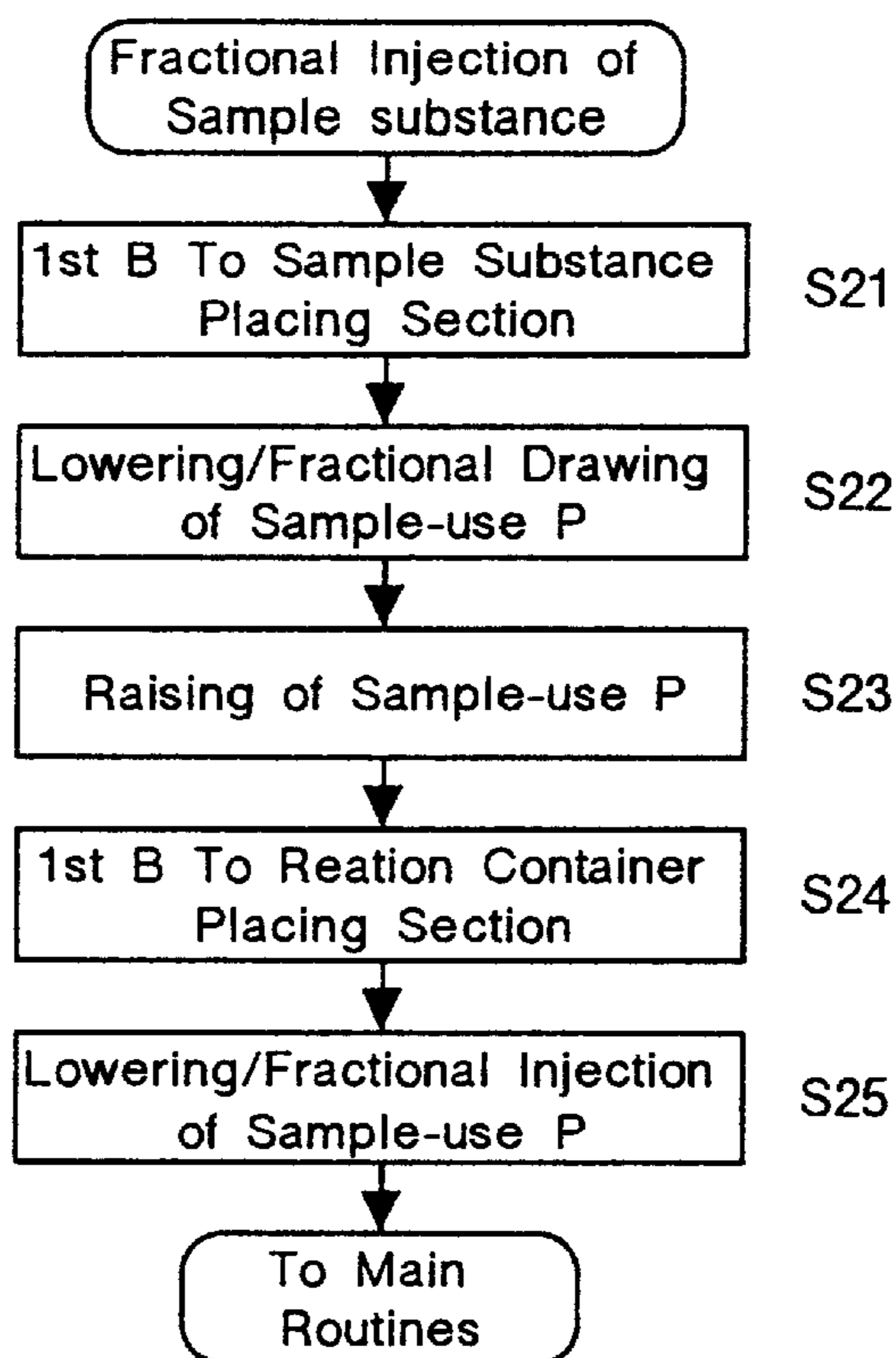


FIG. 11

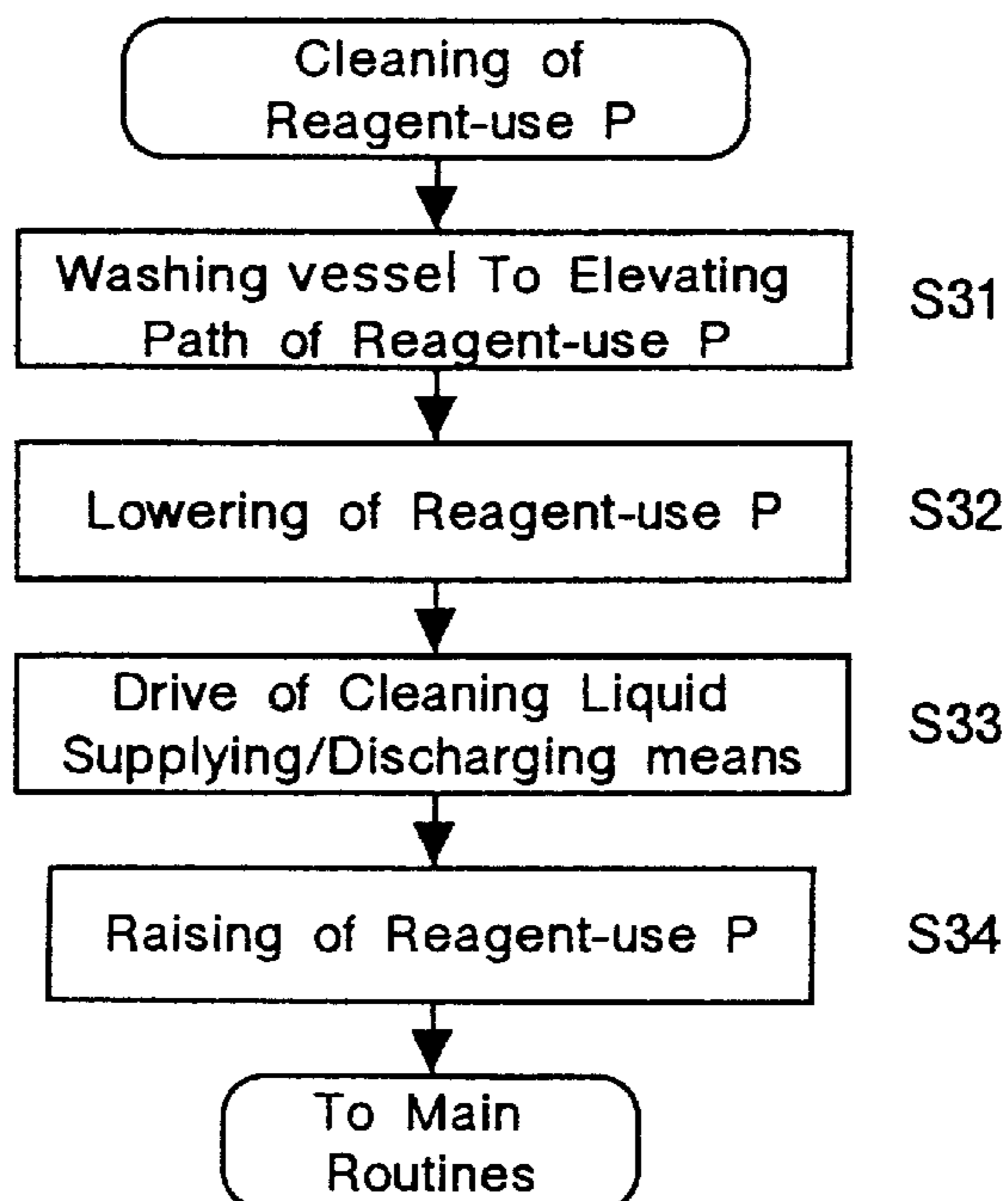


FIG. 12

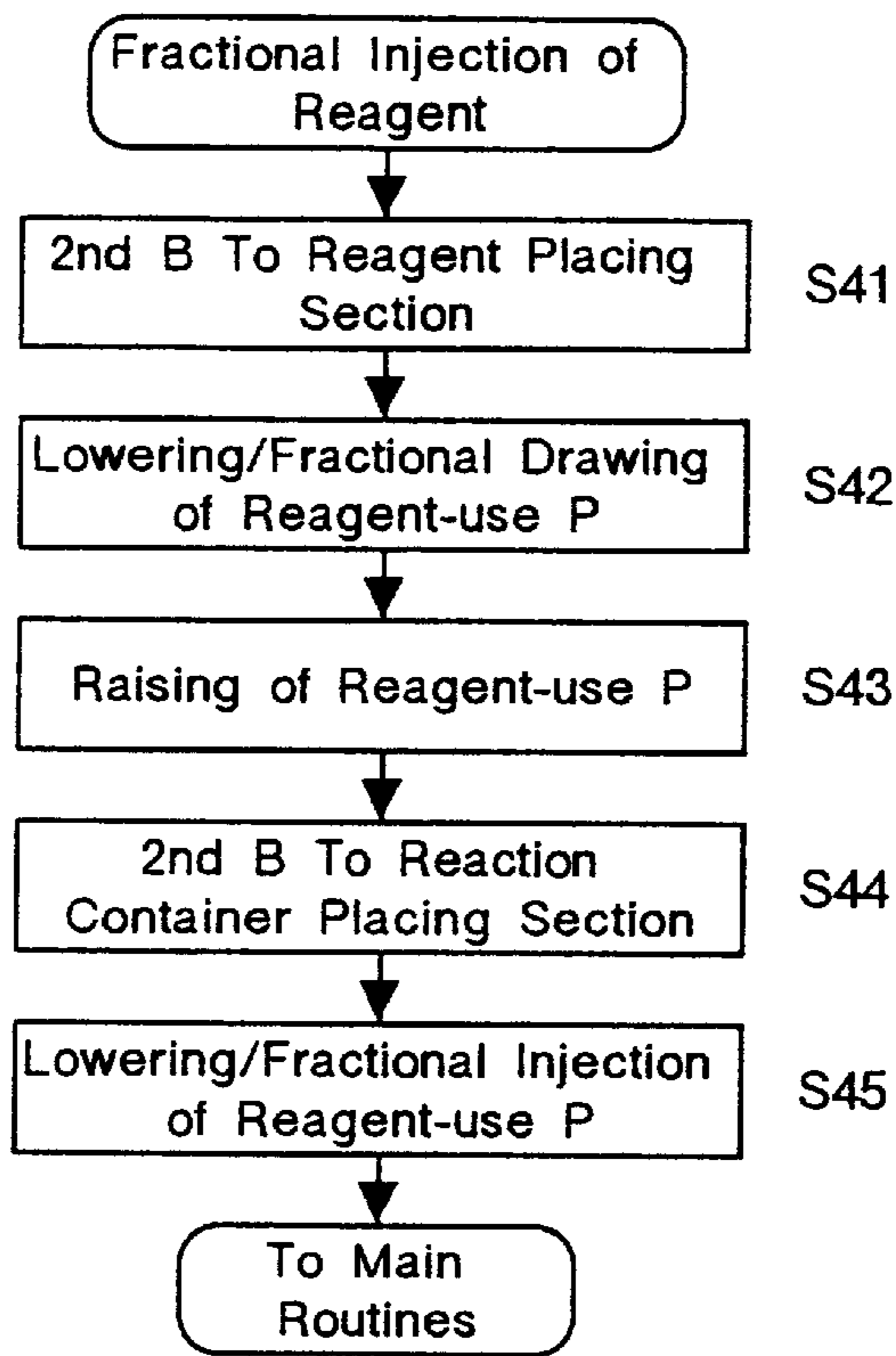


FIG. 13

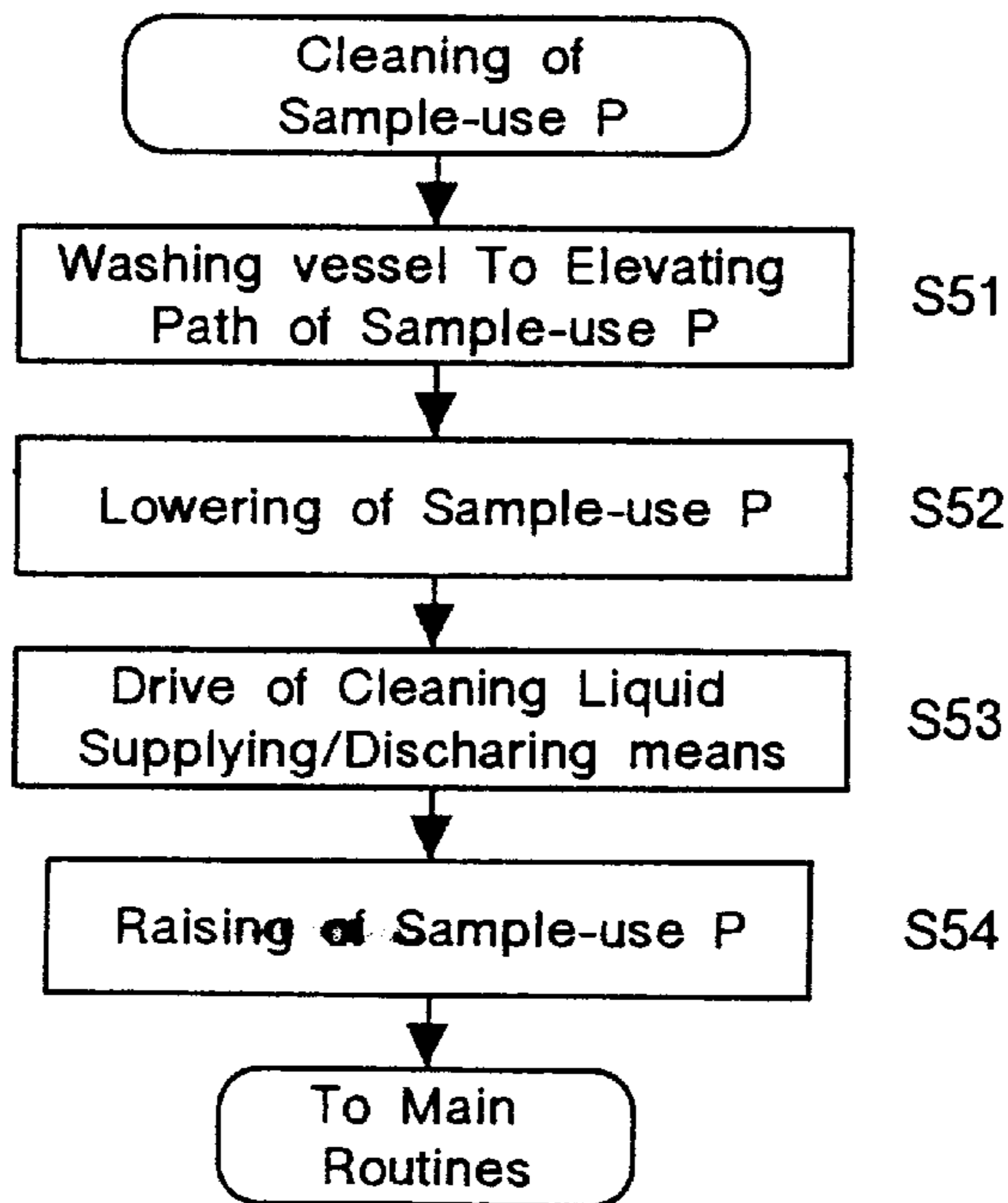


FIG. 14

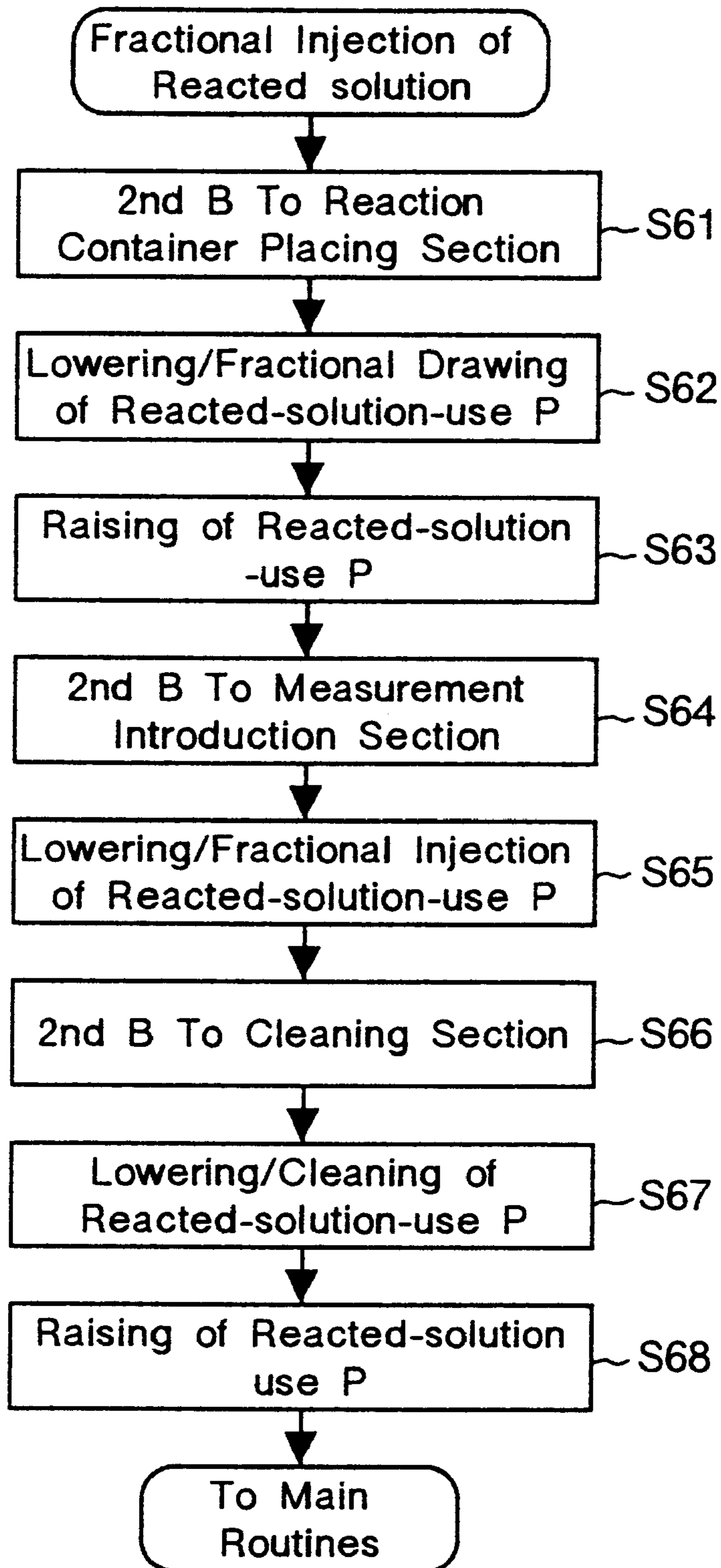


FIG. 15

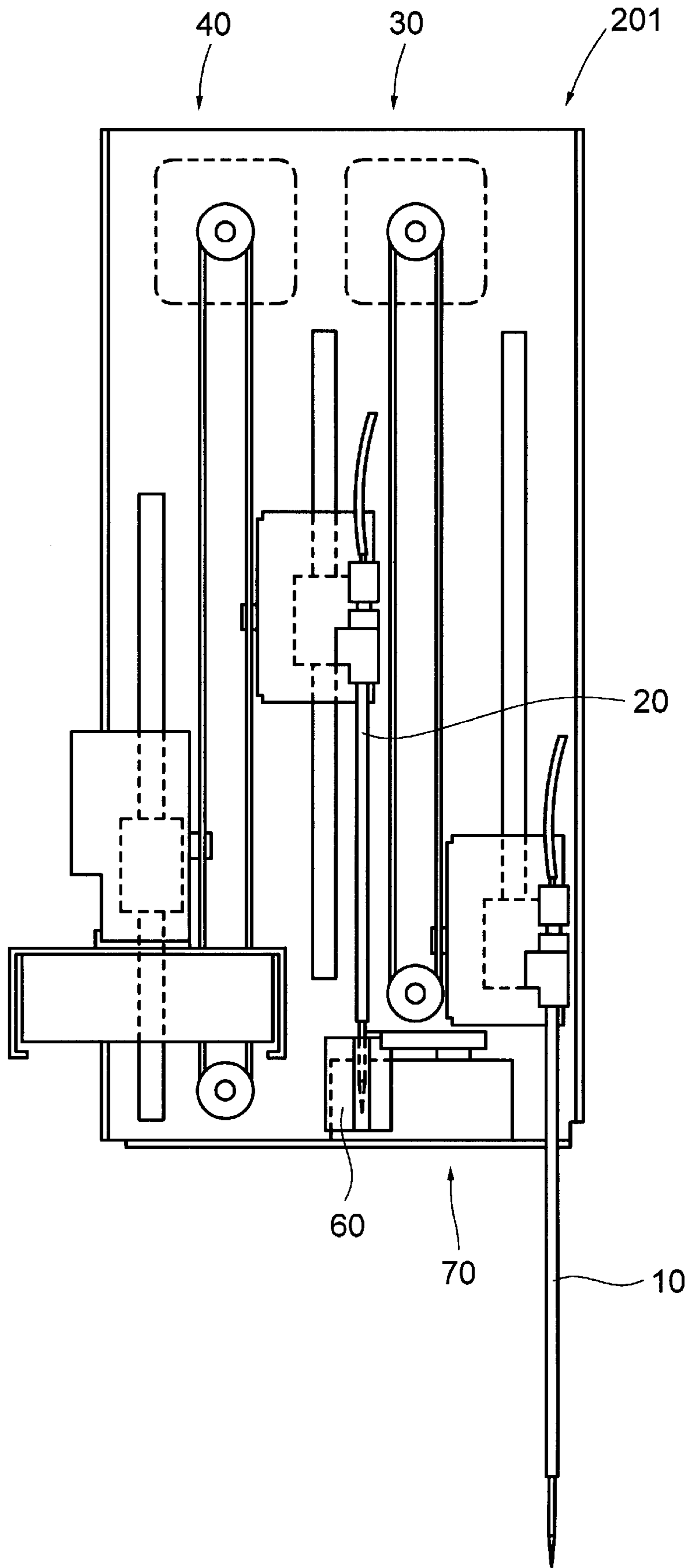
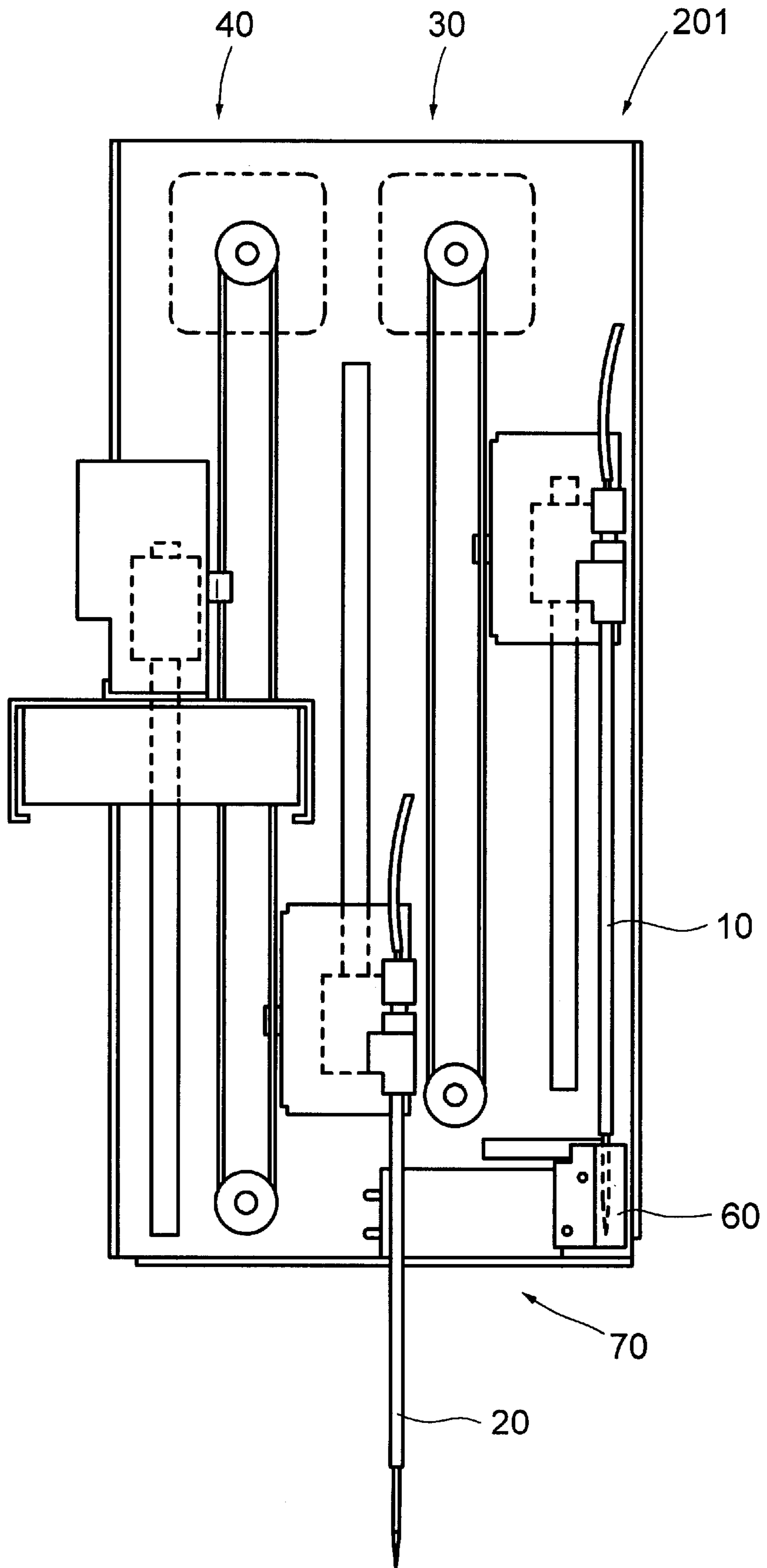


FIG. 16



DISPENSING DEVICE AND IMMUNOASSAY APPARATUS USING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a dispensing device, and an immunoassay apparatus using the same; and more particularly, to a dispensing device comprising a plurality of dispensing pipettes for sucking and discharging a liquid; a pipette elevating means for raising and lowering each pipette; a base to hold the pipette elevating means; a base moving means for moving the base; and a washing vessel for cleaning each pipette which can be efficiently incorporated into an immunoassay apparatus.

2. Description of the Related Art

Generally, a dispensing device is used by being incorporated in an automatic analyzing apparatus such as an immunoassay apparatus. In the dispensing device, each dispensing pipette is moved to a location over each of specimen, reagent, washing and reaction vessels, which are placed on a table of the automatic analyzing apparatus, so as to suck and discharge the specimen and the reagent to be reacted with each other followed by cleaning.

With the conventional type of dispensing device, each pipette must be moved to the washing vessel to be cleaned for the next dispensing operation each time the dispensing of the specimen or the reagent from the pipette is completed. For the automatic analyzing apparatus including this conventional type dispensing device, there has been a need for a dispensing device capable of accelerating the dispensing operation and the cleaning operation and enabling a large quantity of specimen to be analyzed with high efficiency.

SUMMARY OF THE INVENTION

An object of the invention is to provide a dispensing device enabling to accelerate dispensing steps including cleaning step and enabling a large number of specimens to be analyzed with high efficiency.

According to the invention, there is provided a dispensing device comprising at least two dispensing pipettes for sucking and discharging a liquid; a pipette elevating means for selectively raising and lowering each pipette along an elevating path thereof; a base for holding the pipette elevating means; a base moving means for moving the base; a washing vessel in which each pipette is alternately immersed to be cleaned; and a washing vessel moving means for allowing the washing vessel to selectively move between locations in the elevating paths of the pipettes.

Preferably, each dispensing pipette of the invention includes a pipette body and a fluid feeding means such as a syringe or a pump connected to the pipette body, so that the following operations can take effect in an automatic analyzing apparatus such as an immunoassay apparatus. When the pipette body is inserted in a specimen vessel or a reagent vessel, a fluid feeding means connected to the pipette body starts its sucking operation to suck up a required amount of specimen or reagent into the pipette through a piping of a flexible tube or equivalent. Then, when the pipette body is moved to and inserted into to a reaction vessel, the fluid feeding means starts its discharging operation to dispense the predetermined amount of specimen or reagent through the flexible tube. Thereafter, cleaning water or air is sucked into the pipette body and is discharged from the tip thereof. The cleaning water or air may be fed from the tip of the pipette and discharged from the pipette body. The cleaned pipette body is moved again between the next specimen and the reagent.

Preferably, the pipette elevating means comprises a pair of upper and lower horizontal axes mounted on the base; a belt stretched between the horizontal axes; a pipette moving element clamped to the belt for allowing the pipette to be held vertically; and a belt driving motor for driving the belt mounted on the base, wherein the base moving means comprises a threaded shaft including a horizontal shaft, a base moving element threadedly engaged with the threaded shaft and supporting the base, and a threaded shaft driving motor for rotating the threaded shaft.

The pipette elevating means of the invention is moved with precision in a vertical direction by drive of a belt running between pulleys or by drive of ball screw or equivalent.

Further, it is desirable that the pipette elevating means enables two or more pipettes to be selectively raised and lowered so that at least two of the pipettes alternately take positions at different vertical levels.

Desirably, the pipette elevating means is adapted so that a pipette stopping position is preset for each pipette to be stopped when it is lowered into the washing vessel located in the corresponding pipette elevating path.

Also, it is desirable that the pipette stopping position is so preset that the tip of the pipette may not be brought into contact with and damaged by the washing vessel, but the tip portion of the pipette contaminated by the specimen or reagent is immersed in the cleaning liquid in the washing vessel. It is preferable for simplification of control to set each pipette stopping position to have the same vertical level. The presetting of each pipette stopping position may be made arbitrarily depending on their vertical levels at which the pipettes perform the dispensing. The pipette stopping positions may alternatively be determined by a liquid level sensor. An example of the liquid level sensor is one which is used in a washing vessel formed of a dielectric and includes a sensor for sensing a change in capacitance between the washing vessel and the pipette when the tip of the pipette is brought into contact with the liquid in the washing vessel.

Preferably, the base moving means is moved with precision in a horizontal direction by drive of a belt running between pulleys or by drive of ball screw or equivalent.

Further, it is desirable that the base moving means is capable of being linked, in operation, with at least one of the washing vessel moving means, the pipette elevating means, the washing vessel cleaning means, and the fluid feeding means. The washing vessel moving means, the washing vessel cleaning means and the fluid feeding means will be described later.

Preferably, the washing vessel of the invention has a height and a cross section sufficient to receive at least a tip portion of the pipette so that the vessel can contain a predetermined amount of cleaning liquid to rinse the specimen or the reagent adhering to the pipette therefrom. At least one washing vessel is arranged on the base. It is desirable that the washing vessel is formed to receive one pipette body at a time. Alternatively, the washing vessel may be adapted to receive two or more pipette bodies, e.g., a set of pipette bodies arranged in parallel with each other to be raised and lowered simultaneously.

The washing vessel moving means of the invention is formed by an actuator which allows the washing vessel to orderly rotate, swing, or linearly move between locations in the elevating paths of the pipettes defining a starting point and an endpoint of such a movement of the washing vessel. The washing vessel moving means of the invention includes

a means to allow the arms holding the washing vessel to be rotated in forward and backward directions or reciprocated linearly by the actuator or equivalent.

Further, it is preferable that the washing vessel moving means is in the form of an actuator which, when a first pipette is in its lower position, allows the washing vessel to be positioned in place in the elevating path of a second pipette which is in its upper position, and, when the second pipette is in its lower position, allows the washing vessel to be positioned in place in the elevating path of the first pipette which is now in its upper position. Desirably, the washing vessel is connected to a washing vessel cleaning means for introducing a cleaning liquid in and out of the washing vessel, and the pipettes are connected to a fluid feeding means for supplying a cleaning fluid into the pipettes.

Additionally, it is advantageous that the washing vessel moving means comprises (i) a rotary actuator mounted on the base and having a vertical rotary axis and (ii) an arm having one end supported by the vertical rotary axis and the other end supporting the washing vessel.

Preferably, the washing vessel cleaning means comprises a liquid feeding path connected to a lower part of the washing vessel, a liquid discharging path connected to an upper part of the washing vessel, and a washing vessel pump which is connected to the liquid feeding path so that the cleaning liquid can be fed from the lower part of the washing vessel and discharged from the upper part of the washing vessel through the liquid discharging path, wherein the fluid feeding means comprises a quantifying syringe connected to an upper end portion of the pipette and a pipette pump capable of feeding the cleaning liquid to the quantifying syringe.

Preferably, the dispensing device further comprises a vessel sensing means for sensing the washing vessel positioned in place in either of the elevating paths of the pipettes.

Advantageously, the vessel sensing means includes a controlling section to which a magnetic sensor, a micro switch and the like are connected, so that the controlling section can command to clean the pipette when the vessel sensing means senses the washing vessel positioned in place in either of the elevating paths of the pipettes.

Further, the vessel sensing means preferably comprises a magnet fixed to the arm and Hall effect devices which are located in such places in the pipette elevating paths as to be linked in operation with the magnet.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of an automatic analyzing apparatus (an immunoassay apparatus) including a dispensing device according to one embodiment of the invention;

FIG. 2 is a view of the dispensing device of FIG. 1 (showing the pipette on standby);

FIG. 3 is a view of a pipette liquid feeding means of the dispensing device of FIG. 2;

FIG. 4 is a plan view of a washing vessel moving means located in a part of the dispensing device of FIG. 2;

FIG. 5 is a view showing the sectional view of the washing vessel disposed in a washing vessel moving means of FIG. 4 and illustrating the washing vessel liquid feeding means;

FIG. 6 is a perspective view of a reaction plate held by a reaction vessel holding means of the dispensing device of FIG. 2;

FIG. 7 is a view of the second dispensing block disposed in the automatic analyzing apparatus of FIG. 1;

FIG. 8 is a block diagram of a controlling section of the automatic analyzing apparatus of FIG. 1;

FIG. 9 is a flowchart of the control of the automatic analyzing apparatus of FIG. 1;

FIG. 10 is a flowchart of the dispensing of the specimen of FIG. 9;

FIG. 11 is a flowchart of the cleaning of a reagent pipette of FIG. 9;

FIG. 12 is a flowchart of the dispensing of a reagent in FIG. 9;

FIG. 13 is a flowchart of the cleaning of the specimen pipette of FIG. 9;

FIG. 14 is a flowchart of the dispensing of a reacted solution in FIG. 9;

FIG. 15 is a view corresponding to FIG. 2, illustrating the cleaning operation of the reagent pipette and the position of the washing vessel moving means at the time of the dispensing with the specimen pipette; and

FIG. 16 is a view corresponding to FIG. 2, illustrating the cleaning operation of the specimen pipette and the position of the washing vessel moving means at the time of the dispensing with the specimen pipette.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

One example of an apparatus using the dispensing device of the invention is an immunoassay apparatus comprising a table on which specimens including blood, reagents, and reaction vessels are placed; an immunoassay section; a specimen/reagent dispensing section disposed above the table for dispensing the specimen and the reagent into the reaction vessels; and a reacted solution dispensing section for dispensing reacted solutions from the reaction vessels to said measuring section, wherein said specimen/reagent dispensing section is formed by the dispensing device of the invention.

Next, operation of the dispensing device of the invention, applied to an immunoassay apparatus, will be described below. In this example, one of the pipettes is used as a pipette for use in dispensing a specimen (hereinafter referred to as a specimen pipette) and the other is used as a pipette for use in dispensing a reagent (hereinafter referred to as a reagent pipette), for minimization of contamination.

First, the base is moved to a selected specimen by the drive of the base moving means. The specimen pipette, ready for use, is lowered by the pipette elevating means and the tip portion of the same is immersed into the specimen including blood to suck up a required amount of specimen. Then, the base is moved to a selected reaction vessel and the specimen sucked up in the pipette is ejected from the pipette into the reaction vessel. After completion of the ejection, the specimen pipette is raised by the pipette elevating means to be on standby for the next operation.

During this dispensing process of the specimen pipette, the reagent pipette held together with the specimen pipette on the base is in the cleaning process. In the cleaning process, the reagent pipette is immersed into the washing vessel positioned in place in the elevating path of the reagent pipette and is cleaned. After completion of the cleaning, the reagent pipette is raised from the washing vessel by the pipette elevating means. When the reagent pipette is raised to be on standby, the washing vessel is shifted to a location in the elevating path of the specimen pipette by the washing vessel moving means.

Then, the base is moved to the reagent by the drive of the base moving means. The reagent pipette, ready for use, is

lowered by the pipette elevating means and the tip portion of the same is immersed into the reagent to suck up a required amount of reagent. Then, the base is moved to the reaction vessel and the reagent sucked up in the pipette is ejected from the pipette into the reaction vessel. After completion of the ejection, the reagent pipette is raised by the pipette elevating means to be on standby for the next operation.

During this dispensing process of the reagent pipette, the specimen pipette held together with the reagent pipette on the base is in the cleaning process. In the cleaning process, the specimen pipette is immersed into the washing vessel positioned in place in the elevating path of the specimen pipette and is cleaned. After completion of the cleaning, the specimen pipette is raised by the pipette elevating means. When the specimen pipette is raised to be on standby, the washing vessel located in the elevating path of the specimen pipette is shifted from the location in the elevating path of the specimen pipette to the location in the elevating path of the reagent pipette by the washing vessel moving means to be on standby for the next operation.

This constitution of the invention can provide the result that the process of reciprocating the pipettes used for the dispensing to the washing vessel fixed on the table every time, which is required in the conventional dispensing device, is omitted. Also, in tandem with the discharging action of one pipette or the moving action of the base, the other pipette can be cleaned simultaneously. Consequently, the dispensing of specimen or reagent can be continuously carried out without being retarded by the cleaning.

Where the washing vessel moving means is in the form of an actuator which, when one of the pipettes is in its lower position, allows the washing vessel to be positioned in place in the elevating path of the other pipette which is in its upper position, and, when the other pipette is in its lower position, allows the washing vessel to be positioned in place in the elevating path of the one pipette which is in its upper position, it can be ensured that each pipette is not hindered from its lowering motion by the washing vessel when it is lowered to the dispensing position.

Where the washing vessel is connected to a washing vessel cleaning means for introducing a cleaning liquid in and out of the washing vessel, and the pipettes are connected to a fluid feeding means for supplying a cleaning liquid into the pipettes, both the exterior and the interior of each pipette immersed in the washing vessel can be cleaned by use of the washing vessel cleaning means and the fluid feeding means, respectively.

Further, where the base moving means is capable of being linked, in operation, with at least one of the washing vessel moving means, the pipette elevating means, the washing vessel cleaning means, and the fluid feeding means, that can provide the result that at least a part of the cleaning process is performed simultaneously while one of the pipettes held on the base is moved.

Additionally, where the washing vessel moving means comprises a rotary actuator mounted on the base and having a vertical rotary axis and an arm having one end supported by the vertical rotary axis and the other end supporting the washing vessel, that can provide the result that the arm is simply required to swing or pivot around the vertical rotary axis of the rotary actuator to move between the two places. Consequently, the control of the washing vessel moving means can be facilitated.

Also, where the dispensing device further comprises a vessel sensing means for sensing the washing vessel positioned in place in one of the elevating paths of the pipettes,

it can be ensured that the pipettes are prevented from being damaged and also the tip portions of the pipettes are introduced into the washing vessel.

Further, where the pipette elevating means is adapted so that a pipette stopping position is preset for each pipette to be stopped when it is lowered into the washing vessel located in the corresponding pipette elevating path, it can be ensured that the tip portion of the pipette is protected against being brought into contact with and damaged by the washing vessel and also it can be ensured that the tip portion of the pipette with the specimen or reagent adhering thereto is immersed in the cleaning liquid in the washing vessel.

A better understanding of the invention may be provided by referring to the accompanying drawings. FIG. 1 shows an example of an automatic immunoassay apparatus equipped with a dispensing device of an embodiment of the present invention. The basic configuration of the apparatus, including system of reaction, system of measurement and the like, is the same as the known ones. The automatic immunoassay apparatus **200** is constructed mainly of a dispensing device **210** and a table **220** on which a specimen, a reagent and equivalent are to be positioned.

The dispensing device **210** comprises the first dispensing block **201** having two pipettes of the invention, the second dispensing block **202** having one pipette, the first block moving means **203** and the second block moving means **204** which form a base moving means for moving the first and second blocks **201,202** along X and Y axes.

The first dispensing block **201** is constructed mainly of two dispensing pipettes **10, 20**, pipette elevating means **30, 40** for elevating the respective pipettes **10, 20**, and a base **50** holding the pipettes **10, 20** and the pipette elevating means **30, 40**, as shown in FIG. 2.

The dispensing pipettes **10, 20** are attached at the upper end portions thereof to connecting pipes **11, 21** so as to be hung therefrom. Tubes **12, 22** communicating with the pipettes **10, 20** are coupled to the connecting pipes **11, 21**. The respective tubes **12, 22** are connected to a pipette liquid feeding means **80**, as shown in FIG. 3. The pipette liquid feeding means **80** is connected to syringes **83, 84** driven by motors **81, 82**. The syringes **83, 84** are connected to cleaning liquid chambers **87, 88** from which the cleaning liquid supplied by positive pressure from the outside is fed toward the syringes **83, 84** through solenoid valves **85, 86**. This pipette liquid feeding means **80** allows the dispensing of the specimen or the reagent and the cleaning of the interior of the pipettes **10, 20** to be performed by switching of the solenoid valves **85, 86**. The connecting pipes **11, 21** are mounted on the pipette elevating means **30, 40**.

The pipette elevating means **30, 40** comprise vertically extending guide tracks **31, 41** fixed to the base **50**; sliders **32, 42** movable up and down along the guide tracks **31, 41**; belts **34, 44** on which the sliders **32, 42** are fixedly mounted via mounting members **33, 43**; a pair of pulleys **35, 45** between which the belts **34, 44** are stretched in a vertical direction; and motors **36, 46** for rotatively driving one of the pulleys **35, 45**.

The elevating means **30, 40** allow the specimen pipette **10** and the reagent pipette **20** to be raised and lowered by the forward and backward rotations of the motors **36, 46**. The pipettes **10,20** are each stopped at their standby position (an upper position), at their stopping position at which a tip portion **10a, 20a** of each of the pipettes **10, 20** entering a washing vessel **60** mentioned later is stopped and at their dispensing position (a lower position), respectively. At the bottom of the base **50** under the pipettes **10, 20**, there are

provided a washing vessel **60** and a washing vessel moving means **70** for moving the washing vessel **60** horizontally, as shown in FIG. **4**.

The washing vessel **60** is provided with a hole **61** for the tip portion **10a**, **20a** of each of the pipettes **10**, **20** to enter, a cleaning liquid inlet **62** and a cleaning liquid outlet **63** both communication with the hole **61**, as shown in FIGS. **4** and **5**. To the cleaning liquid inlet **62** and the cleaning liquid outlet **63** is connected a cleaning liquid feeding means **90** as shown in FIG. **5**. The cleaning liquid feeding means **90** comprises a pump **91** and a cleaning liquid chamber **92** connected to the pump **91** and enables the cleaning liquid stored in the hole **61** of the washing vessel **60** to be replaced at appropriate times. The cleaning liquid outlet **63** is connected to a discharge liquid reservoir **93**. A magnet **64**, which forms a washing vessel sensing means mentioned later, is provided on an outer wall of the washing vessel **60**.

The washing vessel moving means **70** comprises an arm **71** holding the washing vessel **60** at the one end thereof and a driving means **73** including a rotary actuator capable of reciprocally pivoting around a pivot shaft **72** provided at the other end of the arm **71**. The pivotal motion of the arm **71** is controlled via a controlling section not shown by use of the magnet **64** provided on the washing vessel **60** and Hall effect devices **51**, **52** provided on a bottom of the base **50**.

The Hall effect devices **51**, **52** are spaced apart from each other in such a manner that when the hole **61** of the washing vessel **60** is positioned in place in the elevating path of the specimen pipette **10**, the Hall effect device **51** confronts the magnet **64** in proximity thereto, while on the other hand, when the opening **61** of the washing vessel **60** is positioned in place in the elevating path of the reagent pipette **20**, the Hall effect device **52** confronts the magnet **64** in proximity thereto. When the magnet **64** at the arm **71** swinging in a counterclockwise direction (in a direction indicated by an arrow depicted in a solid line in FIG. **4**) is brought into the proximity of the Hall effect device **51** by the driving means **73** driven in the forward direction, the swinging motion of the arm **71** caused by the driving means **73** is stopped, so that the hole **61** of the washing vessel **60** is positioned in place in the elevating path of the specimen pipette **10**. When a command to switch the position of the washing vessel **60** is issued from the controlling section, the rotation of the driving means **73** is reversed to allow the arm **71** to swing in a clockwise direction (in a direction indicated by an arrow depicted in a chain line in FIG. **4**).

When the magnet **64** at the arm **71** swinging in the clockwise direction is brought into the proximity of the Hall effect device **52**, the swinging motion of the arm **71** caused by the driving means **73** is stopped, so that the hole **61** of the washing vessel **60** is positioned in place in the elevating path of the reagent pipette **20**. When a command to switch the position of the washing vessel **60** is issued from the controlling section, the driving means **73** is driven in the forward direction again, so that the hole **61** of the washing vessel **60** is positioned in place in the elevating path of the specimen pipette **10**. In this manner, the washing vessel moving means **70** allows the washing vessel **60** to be selectively positioned in place in each of the elevating paths of the pipettes **10** and **20**. Thus, the washing vessel moving means **70** interlocking in operation with the aforesaid pipette elevating means **30**, **40** enables the two pipettes **10**, **20** to be alternately cleaned at their pipette stopping positions with the single washing vessel **60**.

There is provided a reaction vessel holding means **110** at the rear of the belt **44** to which the reagent pipette **20** is

disposed. The reaction vessel holding means **110** is attached via an attachment **113** to a slider **112** movable up and down along a guide track **111** mounted to the base **50** in parallel with said guide track **31**. The holding means **110** includes a mounting member **114** having a U-like shape with the front ends thereof folded inside, in other words, with a center part of a bottom side of rectangle cut out. The mounting member **114** is provided with a vertical member **115** and a positioning sensor **116** fixed to the vertical member **115**.

The mounting member **114** is provided at the front ends thereof with bent portions **117**, **118** to which handles **101**, **102** of a reaction plate **100** is fitted for holding the reaction plate **100**. Handle **101** of the reaction plate **100** is provided at both lower ends thereof with holding projections **103**, **104**, as shown in FIG. **6**. The holding projections **103**, **104** are so located as to catch the bent portion **117** from the outside, so that the reaction plate **100** is held in place and does not move out of position, when being lifted up.

Further, a cylindrical member **119** having a rounded top is provided in the base **50**. The cylindrical member **119** is fitted into a reaction vessel **100a** of the reaction plate **100** when the reaction plate **100** is lifted up by the holding means **110**. Thus, the reaction plate **100** is firmly held without moving out of position by the longitudinal or transverse movement.

The reaction plate **100** is an integrally-molded transparent plate of synthetic resin. Each reaction plate has, for example, 25 reaction vessels **100a** having 5 vessels on each side (5×5) and is integrally formed of synthetic resin in such a manner that the vessels **100a** are adjoined to each other through a base plate **100b**. Each vessel **100a** has an internal diameter of for example about 8 mm and a height of for example about 24 mm. The reaction plate **100** is substantially square in shape, about 70 mm on each side, for example, when viewed from the above.

An upper end and a lip portion of each reaction vessel **100a** is located higher than the base plate **100b** (by 6 mm in this embodiment), so that a liquid in the reaction vessel **100a** seldom spills out and also a liquid spilt over the base plate **100b** seldom enters the vessel **100a**. The reaction plate **100** is partially cut out at a corner **107** for the positioning thereof. Each vessel **100a** is provided at its bottom with a recess **108**, which contributes to unfluctuated dimension in production and ensures a stable mounting to the apparatus.

With this construction, according as the holding means **110** is lowered by the drive of the pipette elevating means **40** for holding or releasing the reaction plate **100**, the pipette **20** is raised and thus does not hinder the holding means from holding or releasing the reaction plate **100**. Likewise, according as the pipette **20** is lowered, the holding means **110** is raised and thus does not hinder the pipette **20** from the dispensing operation.

The second dispensing block **202** is constituted mainly of one pipette **120** for use in dispensing of a reacted solution (hereinafter referred to as a reacted solution pipette), a pipette elevating means **130** for raising and lowering the reacted solution pipette **120**, and a base **150** holding the pipette **120** and the elevating means **130**, as shown in FIG. **7**.

The reacted solution pipette **120** is attached at its upper end portion to a connecting pipe **121** so as to be hung therefrom. A tube **123** communicating with the pipette **120** is coupled to the connecting pipe **121**. The tube **123** is connected to a pipette liquid feeding means **80** equivalent to the one shown in FIG. **3** so that an interior of the pipette **120** can be cleaned. The connecting pipe **121** is mounted to the pipette elevating means **130**.

Like the abovesaid pipette elevating means **30**, the pipette elevating means **130** comprises a vertically extending guide track **131** fixed to the base **150**; a slider **132** movable up and down along the guide track **131**; a belt **134** to which the slider **132** is fixedly mounted via a mounting member **133**; a pair of pulleys **135** between which the belt **134** is stretched in a vertical direction; and a motor **136** for rotatively driving one of the pulleys **135**.

The elevating means **130** allows the reacted solution pipette **120** to be raised and lowered by forward and backward rotations of the motor **136**. Nothing corresponding to the washing vessel **60** and the washing vessel moving means **70** included in the first dispensing block **201** is mounted on the base **150**.

A table **220** is provided under the dispensing device **210** (See FIG. 1). An upper surface of the table **220** is partitioned into a specimen placing section **1** where a specimen rack is placed, a reagent placing section **2** where a reagent rack is placed, an empty vessel placing section **3** where an empty reaction vessel is placed, a reaction vessel placing section **4** where a vessel containing reacted solution is placed, a used vessel placing section **5** where a used reaction vessel is placed, a measurement introducing section **6** for introducing a reacted solution into system of measurement, and a pipette cleaning section **7**. These sections are all arranged in one plane.

Further, the input and output sections mentioned above are electrically connected to a controlling section mentioned later. FIG. 8 is a block diagram of an immunoassay apparatus **200**.

The immunoassay apparatus **200** has the controlling section **160** including a microcomputer comprising CPU, ROM, RAM, a timer, a counter, and the like. The input section, including an external key input unit **161** (not shown), the Hall effect devices **51**, **52**, and the reaction vessel positioning sensor **116**, is connected to the controlling section **160**. Also, the output section, including block moving means **203**, **204**, the pipette elevating means **30**, **40**, **130**, the washing vessel moving means **70**, the washing vessel liquid feeding means **90** and the pipette liquid feeding means **80**, is connected to the controlling section **160** together with other input and output section **162**.

Next, with reference to the flowcharts of FIGS. 9 to 14, operation of the immunoassay apparatus **200** of the embodiment will be described below.

First, the input and output sections are reset at step **M1**. Second, the reaction plate **100** is moved at step **M2**, at which the first dispensing block **201** is moved by the drive of the first block movable means **203** to a location over the empty vessel placing section **3** and then the holding means **110** is lowered by the drive of the pipette elevating means **40** to hold the reaction plate **100**. After holding the reaction plate **100**, the holding means is raised and is moved to a location over the reaction vessel placing section **4**. Then, the holding means **110** is lowered to put the reaction plate **100** in place on the reaction vessel placing section **4**.

Then, the dispensing of the specimen is performed at step **M3**. In detail, the dispensing of the specimen is performed in the order shown by the subroutines of FIG. 10: First, at step **S21** the first dispensing block **201** is moved to a location over the specimen placing section **1** and is stopped at a location over a selected specimen rack. Then, at step **S22** the tip portion of the specimen pipette **10** is lowered into the selected specimen rack, so as to suck up the specimen.

After the specimen pipette **10** is raised and stopped at step **S23**, the first dispensing block **201** is moved to a location

over the reaction vessel placing section **4** and then the specimen pipette **10** is stopped at a location over a selected reaction vessel **100a** on the reaction plate **100** at step **S24**. Then, at step **S25** the tip portion of the specimen pipette **10** is lowered into the selected reaction vessel **100a** so as to dispense the specimen thereinto. During this process, the washing vessel **60** remains on the reagent pipette **20** side. After completion of the dispensing of the specimen, the specimen pipette **10** is raised to be on standby for the next operation.

During this process, the reagent pipette **20** is in the cleaning process at step **M4**. In detail, the cleaning process of the reagent pipette **20** is performed in the order shown by the subroutines of FIG. 11: First, the washing vessel **60** is positioned in place in the elevating path of the reagent pipette **20** at step **S31**. The hole **61** of the washing vessel **60** is supplied in advance with a cleaning liquid. Then, at step **S32** the tip portion of the reagent pipette **20** is lowered into the washing vessel **60** and is stopped at its pipette stopping position, as shown in FIG. 15.

At step **S33** the closing and opening of the solenoid valve **86** connected to the reagent pipette **20** and the drive of the motor **82** allow the cleaning liquid from the pipette liquid feeding means **80** to flow into the reagent pipette **20** through the syringe **84**, so as to clean the interior of the pipette **20**. Further, the cleaning liquid is additionally supplied to the washing vessel **60** from the cleaning liquid chamber **92** of the washing vessel liquid feeding means **90**. The additional cleaning liquid fed from the cleaning liquid inlet **62** forces the wasted cleaning liquid in the washing vessel **60** to be discharged from the cleaning liquid outlet **63**, cleaning simultaneously the exterior of the reagent pipette **20** at the tip portion.

After completion of the cleaning, the reagent pipette **20** situated in the washing vessel **60** is raised by the pipette elevating means **40** at step **S43**. When the pipette **20** is raised to be on standby for the next operation, the washing vessel **60** located in the elevating path of the reagent pipette **20** is shifted to a place in the elevating path of the specimen pipette **10** by the washing vessel moving means **70**.

After completion of the dispensing of the specimen at step **M3**, the dispensing of the reagent is performed at step **M5**. In detail, the dispensing of the reagent is performed in the order shown by the subroutines of FIG. 12: First, at step **S41** the second dispensing block **202** is moved to a location over the reagent placing section **2** and is stopped at a location over a selected reagent rack. Then, at step **S42** the tip portion of the reagent pipette **20** is lowered into the selected reagent rack to suck up the reagent.

After the reagent pipette **20** is raised and stopped at step **S43**, the second dispensing block **202** is moved to a location over the reaction vessel placing section **4** at step **44** and then the reagent pipette **20** is stopped at a location over the reaction vessel **100a** into which the specimen has been dispensed. Then, at step **S45** the reagent pipette **20** is lowered and the tip portion of the same enters the reaction vessel **100a** to dispense the reagent thereinto. After completion of the dispensing of the reagent, the reagent pipette **20** is raised to be on standby for the next operation.

During this process, the specimen pipette **10** is in the cleaning process at step **M6**. In detail, the cleaning process of the pipette **10** is performed in the order shown by the subroutines of FIG. 13: First, the washing vessel **60** containing a cleaning liquid is positioned in place in the elevating path of the specimen pipette **10** at step **S51**.

Then, at step **S52** the tip portion of the specimen pipette **10** is lowered into the washing vessel **60** and is stopped at the pipette stopping position, as shown in FIG. 16.

At step S53 the solenoid valve 85 connected to the specimen pipette 10 opens and the cleaning liquid flows into the specimen pipette 10 through the syringe 83 by the drive of the motor 81, so as to clean the interior of the pipette 10. Further, the washing vessel liquid feeding means 90 is driven so that the tip portion of the pipette 10 is immersed in the cleaning liquid for cleaning the exterior of the same.

The cleaning liquid thus supplied is discharged into the reservoir 93 of the washing vessel liquid feeding means 90. After completion of the cleaning, the specimen pipette 10 in the washing vessel 60 is raised by the pipette elevating means 30 at step S54. When the pipette 10 is raised to be on standby for the next operation, the washing vessel 60 located in the elevating path of the specimen pipette 10 is shifted to a place in the elevating path of the reagent pipette 20 by the washing vessel moving means 70.

Then, the dispensing of the reacted solution is made at step M7. In detail, the dispensing of the reacted solution is performed in the order shown by the subroutines of FIG. 14: First, at step S61 the second dispensing block 202 is moved to a location over the reaction vessel placing section 4 and is stopped at a location over the reaction vessel 100a on the reaction plate 100 containing the reacted solution produced by the dispensing of said specimen and said reagent. Then, at step S62 the tip portion of the reacted solution pipette 120 is lowered into the reaction vessel 100a to suck up the reacted solution. If the specimen is of high concentration, it is diluted by sucking up, with the specimen pipette 10, a required amount of diluent liquid which is placed in advance in the reagent placing section 1 and dispensing the diluent liquid into the reaction vessel 100a.

After the reacted solution pipette 120 is raised and stopped at step S63, the second dispensing block 202 is moved to a location over the measurement introducing section 6 at step S64. Then, at step S65 the tip portion of the reacted solution pipette 120 is lowered into the measurement introducing section 6 to dispense the reacted solution thereinto. The reacted solution thus dispensed into the measurement introducing section 6 is measured by a measuring equipment with an optical system (not shown) the data on blood is output to a monitor which is connected to the measuring equipment.

Then, at step S66 the reacted solution pipette 120 is raised and the second dispensing block 202 is moved to a location over the pipette cleaning section 7. Then, at step S67 the reacted solution pipette 120 stopped at a location over the pipette cleaning section 7 is lowered and the tip portion of the same enters the cleaning section 7. Next, the tip portion of the pipette 120 is immersed into a cleaning liquid in a cleaning vessel, (not shown), in the pipette cleaning section 7 so that the exterior of the tip portion of the pipette 120 is cleaned, while the interior of the pipette is cleaned via the drive of a syringe, not shown, connected to the reacted solution pipette 120 and the power source. The wasted cleaning liquid is discharged from the washing vessel by a cleaning liquid fluid feeding means connected to the pipette cleaning section 7. After completion of the cleaning, at step S68 the reacted solution pipette 120 is raised to be on standby for the next operation by the pipette elevating means 30.

Then, at step M8, judgement is made on whether or not the dispensing of the reacted solution into all or selected reaction vessels on the reaction plate 100 is completed and replacement of the reaction plate 100 is needed. If the judgement is such that no replacement of the plate 100 is necessary, then the procedure goes to step M3. On the other

hand, if the judgement is such that the replacement of the plate 100 is necessary, then the procedure goes to step M9.

At step M9, disposal of the reaction plate 100 is performed. In detail, at this step the first dispensing block 201 is moved to a location over the reaction vessel placing section 4 by the drive of the first block moving means 203, and then the holding means 110 is lowered by the drive of the pipette elevating means 40 to hold the used reaction plate 100. Upon holding the used reaction plate 100, the holding means 110 is raised and is moved to a location over the used vessel placing section 5, and then is lowered to put the used reaction plate 100 on the reaction vessel placing section 5.

Then, at step M10 judgement is made on whether or not a command to stop the dispensing device 210 has been issued. If the judgement is such that the command to stop the dispensing device 210 has been issued, then the dispensing operation is terminated. On the other hand, if the judgement is such that the no command to stop the dispensing device 210 has been issued, then the procedure goes to step M2 to continue the dispensing operation.

In the dispensing device 210 of the above-described embodiment of the invention, since the pipettes 10, 20 disposed in the base 50 are cleaned by use of the washing vessel 60 and the washing vessel moving means 70 provided on the same base 50, the dispensing of the specimen or the reagent, the movement of the base 50, and the cleaning of the pipette 10 or 20 are performed simultaneously. Thus, the respective operation of the dispensing, the movement and the cleaning can be performed continuously with no waiting time involved during the transition from one operation to the next. As a result of this, the dispensing process including the cleaning process can be accelerated for handling a number of specimens with high efficiency.

Advantages of the dispensing device of the invention include the following. With the dispensing device of the invention, a plurality of pipettes situated in the base can be cleaned with the washing vessel and the washing vessel moving means both situated in the same base, so that the cleaning of a pipette can be performed simultaneously with the dispensing action by another pipette or the moving action of the base. Thus, the dispensing of the specimen or the reagent can be continuously carried out without being retarded by the cleaning. This can provide the result that the reciprocating motion of the used pipettes to the washing vessel fixed on the table at each dispensing action, which is required for the conventional dispensing device, can be omitted, thereby substantially saving the time required for each dispensing operation.

Where the washing vessel moving means is in the form of an actuator which, when one of the pipettes is in its lower position, allows the washing vessel to be positioned in place in the elevating path of the other pipette which is in its upper position, and, when the other pipette is in its lower position, allows the washing vessel to be positioned in place in the elevating path of the one pipette which is in its upper position, it can be ensured that each pipette is not hindered from its lowering motion by the washing vessel when it is lowered to the dispensing position. Consequently, the shifting operation of the washing vessel and the elevating operation of the two pipettes can be controllably associated with each other with ease.

Where the washing vessel is connected to a washing vessel cleaning means for introducing a cleaning liquid in and out of the washing vessel, and the pipettes are connected to a fluid feeding means for supplying a cleaning liquid into the pipettes, both the exterior and interior of each pipette can be cleaned in the washing vessel in a very short time.

Further, where the base moving means is capable of being linked, in operation, with at least one of the washing vessel moving means, the pipette elevating means, the washing vessel cleaning means, and the fluid feeding means, that can provide the result that at least part of the cleaning process can be performed simultaneously while one of the pipettes held on the base is moved. Accordingly, the time required for each dispensing operation can be substantially saved.

Additionally, where the washing vessel moving means comprises a rotary actuator mounted on the base and having a vertical rotary axis and an arm having one end supported by the vertical rotary axis and the other end supporting the washing vessel, that can provide the result that the arm is simply required to swing or pivot around the vertical rotary axis of the rotary actuator to move between the two places. Therefore, a facilitated control of the washing vessel moving means can be provided and also simplification of the device can be achieved.

Also, where the dispensing device further comprises a vessel sensing means for sensing the washing vessel positioned in place in either of the elevating paths of the pipettes, it can be ensured that in the pipettes are prevented from being damaged and also the tip portions of the pipettes are introduced into the washing vessel.

Thus, the invention can provide a dispensing device capable of enhancing efficiencies of the dispensing operations including the cleaning operations for handling a number of specimens efficiently.

What is claimed is:

1. A dispensing device comprising:

at least two dispensing pipettes for sucking and discharging liquid;

a pipette elevating means for holding the pipettes and selectively raising and lowering each pipette along an elevating path thereof;

a washing vessel in which each pipette is alternately immersed to be cleaned;

a washing vessel moving means for holding the washing vessel and allowing the washing vessel to selectively move between locations in the elevating paths of the pipettes;

a base for holding the washing vessel moving means for washing vessel movement between the elevating path locations and for holding the pipette elevating means for movement of each pipette into the washing vessel when the washing vessel is in the pipette's elevating path; and

a base moving means for moving the base;

whereby one pipette can be cleaned simultaneously with a discharging or a sucking action of the other pipette or a moving action of the base.

2. The dispensing device according to claim 1, wherein the washing vessel moving means is in the form of an actuator which, when a first pipette is in its lower position, allows the washing vessel to be positioned in place in the elevating path of a second pipette which is in its upper position, and, when the second pipette is in its lower position, allows the washing vessel to be positioned in place in the elevating path of the first pipette which is in its upper position.

3. The dispensing device according to claim 1 or 2, wherein the first pipette is a specimen pipette for use in

dispensing a specimen and the second pipette is a reagent pipette for use in dispensing a reagent.

4. The dispensing device according to claim 1, wherein the washing vessel is connected to a washing vessel cleaning means for introducing a cleaning liquid in and out of the washing vessel, and the pipettes are connected to a fluid feeding means for supplying a cleaning liquid into the pipettes.

5. The dispensing device according to claim 4, wherein the base moving means is capable of interlocking in operation with at least one of the washing vessel moving means, the pipette elevating means, the washing vessel cleaning means, and the fluid feeding means.

6. The dispensing device according to claim 1, wherein the washing vessel moving means comprises a rotary actuator mounted on the base and having a vertical rotary axis and an arm having one end supported by the vertical rotary axis and the other end supporting the washing vessel.

7. The dispensing device according to claim 1 or 2, further comprising a vessel sensing means for sensing the washing vessel positioned in place in one of the elevating paths of the pipettes.

8. The dispensing device according to claim 7, wherein the vessel sensing means comprises a magnet fixed to the arm and Hall effect devices which are located in such places in the pipette elevating paths as to be linked in operation with the magnet.

9. The dispensing device according to claim 1, wherein the pipette elevating means comprises a pair of upper and lower horizontal axes mounted on the base; a belt stretched between the horizontal axes; a pipette moving element clamped to the belt for allowing the pipette to be held vertically; and a belt driving motor for driving the belt mounted on the base, wherein the base moving means comprises a threaded shaft including a horizontal shaft, a base moving element threadedly engaged with the threaded shaft and supporting the base, and a threaded shaft driving motor for rotating the threaded shaft.

10. The dispensing device according to claim 4, wherein the washing vessel cleaning means comprises a liquid feeding path connected to a lower part of the washing vessel, a liquid discharging path connected to an upper part of the washing vessel, and a washing vessel pump which is connected to the liquid feeding path so that the cleaning liquid can be fed from the lower part of the washing vessel and discharged from the upper part of the washing vessel through the liquid discharging path, wherein the fluid feeding means comprises a quantifying syringe connected to an upper end portion of the pipette and a pipette pump capable of feeding the cleaning liquid to the quantifying syringe.

11. An immunoassay apparatus comprising a table on which specimens including blood, reagents, and reaction vessels are placed; an immunoassay section; a specimen/reagent dispensing section disposed above the table for dispensing the specimen and the reagent into the reaction vessels; and a reacted solution dispensing section for dispensing reacted solutions from the reaction vessels to said measuring section, wherein said specimen/reagent dispensing section is formed by the dispensing device according to claim 1.